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Impact of Interchanging VOCs on the Performance of Trickle-Bed Air Biofilter

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Introduction

Conceptually identical process to the biofilter

- Microbial attachment: Synthetic inorganic or polymeric media
- Intermittent delivery of Nutrient & Buffer to the media

⇒ ✓ **Consistent Nutrient & pH control**

✓ **Optimizing the waste utilizing kinetics**

Trickle-Bed Air Biofilter (TBAB)

- **Consistent**
- **Long-term**
- **High**

Removal Performance

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Introduction

for more successful application in industry

Source Characteristics

- Transient loading
- VOCs composition
- Emission mode: non-use periods

Biofilter Maintenance

- Biomass accumulation
- Microbial activity

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Objective

Characterization of TBAB performance under adverse operating conditions

- **Effect of step-change in influent concentration**
- **Effect of non-use periods**
- **Effect of interchanging the feed VOCs**
- **Effect of VOCs composition**

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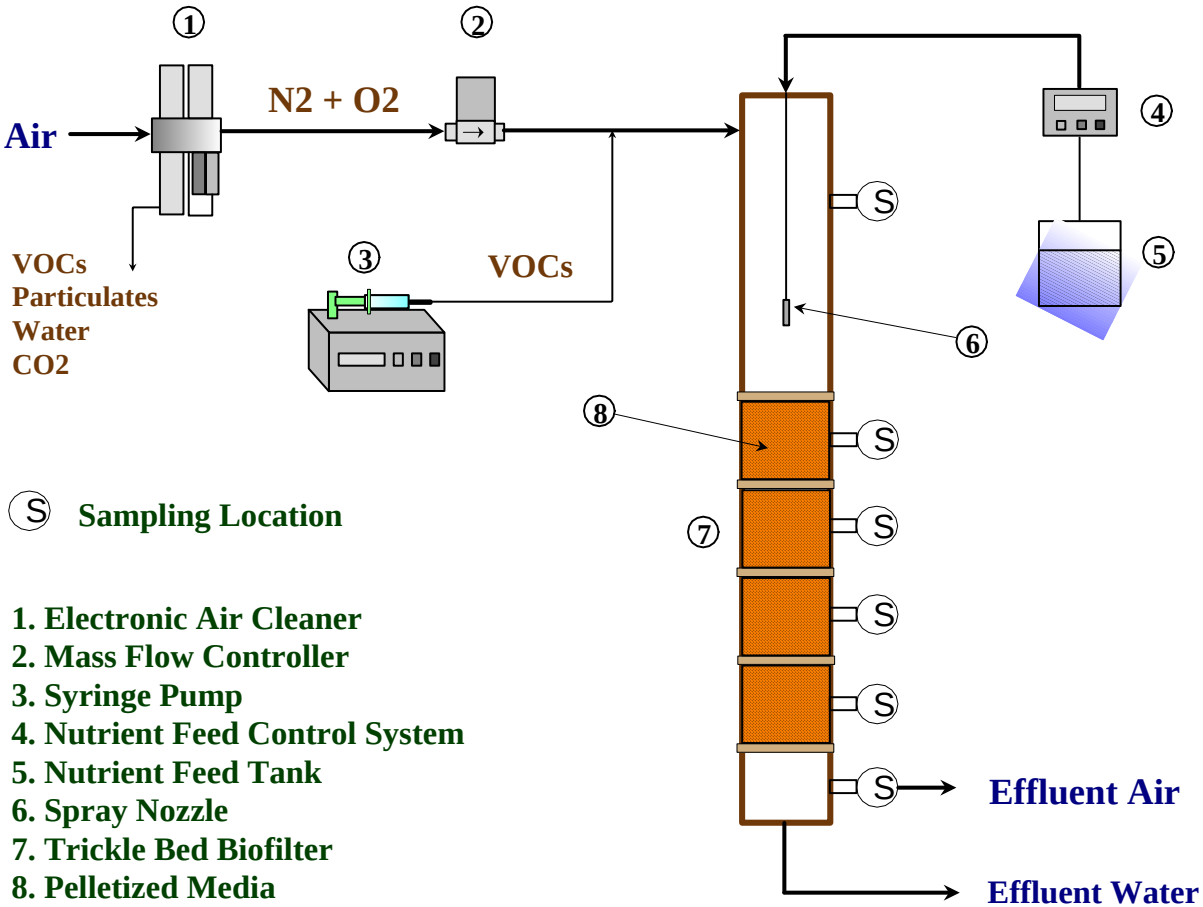
Materials and Methods

- **Reactor** : Independent lab-scale TBAB
- **Media**: pelletized biological support media

Materials and Methods



S Sampling Location

1. Electronic Air Cleaner
2. Mass Flow Controller
3. Syringe Pump
4. Nutrient Feed Control System
5. Nutrient Feed Tank
6. Spray Nozzle
7. Trickle Bed Biofilter
8. Pelletized Media

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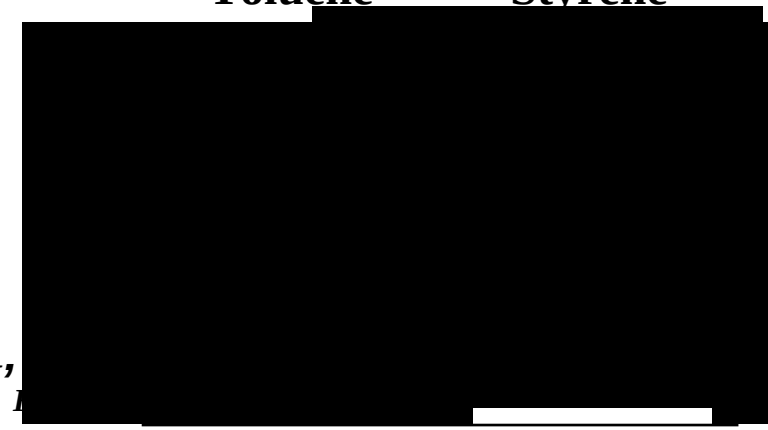
Materials and Methods

- **Feed VOCs**

	Hydrophobic compounds		Hydrophilic compounds	
	Toluene	Styrene	Methyl ethyl	Methyl isobutyl
K'_H				
$Log\ K_{ow}$	2.58	3.16	0.28	1.09

K'_H = dimensionless Henry's law constant, K_{ow} = Octanol-water partition coefficient

Materials and Methods

- **Operating Condition**

- **Sequence of Feed VOCs**

  Styrene → MEK → Toluene → MIBK → Styrene

- **Inlet concentration of feed VOCs**

  50 ppmv ~ the maximum allowable inlet concentration

- **Flow rate**
  - **Nutrient solution: 1.5 L/day**
  - **Air: 1.35 L/min (EBRT = 2.02 min)**

- **Biomass control : Periodic in-situ backwashing**

  Frequency: 1 hour of duration / a week

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Results

- **Previous Study**
  - **Removal capacity of single VOCs**

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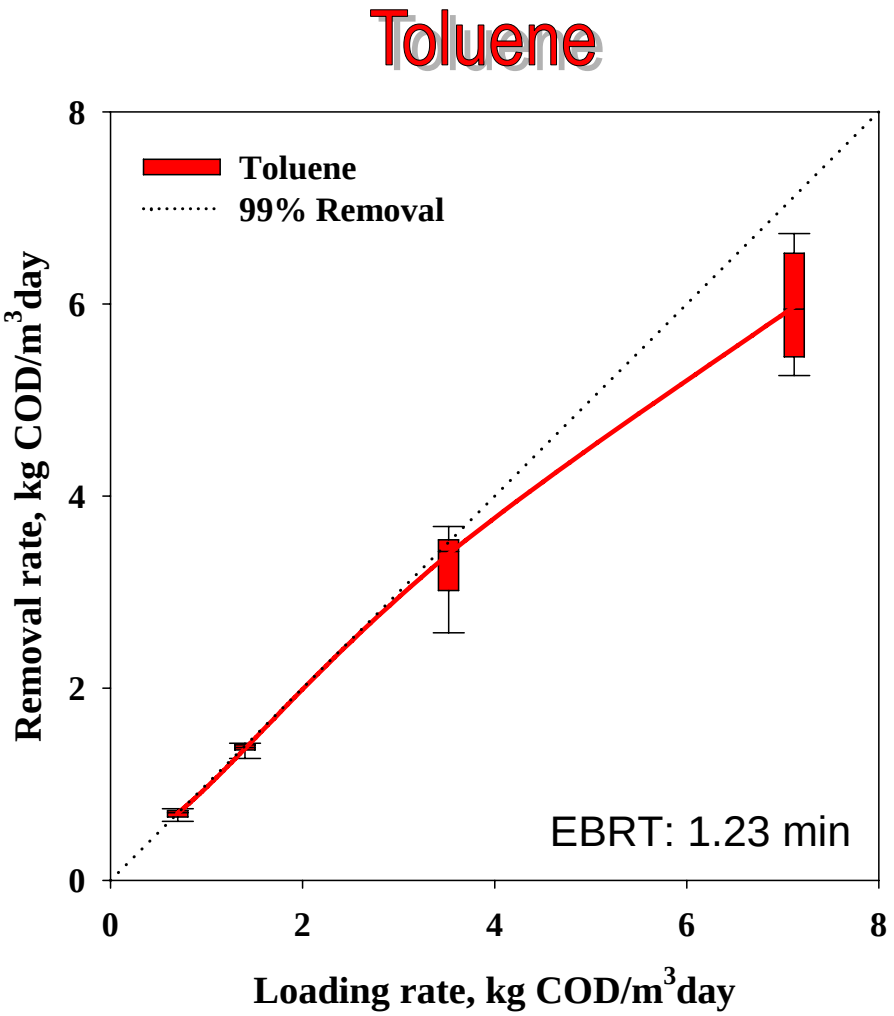
Results

Previous Study

- Critical loading
  3.5 kg COD/m^3·day
  (46.6 g/m^3·hr)
- Maximum removal capacity
  6.0 kg COD/m^3·day
  (79.9 g/m^3·hr)

Current study (EBRT: 2.02 min)
→ Inlet Conc. = 400 ppmv

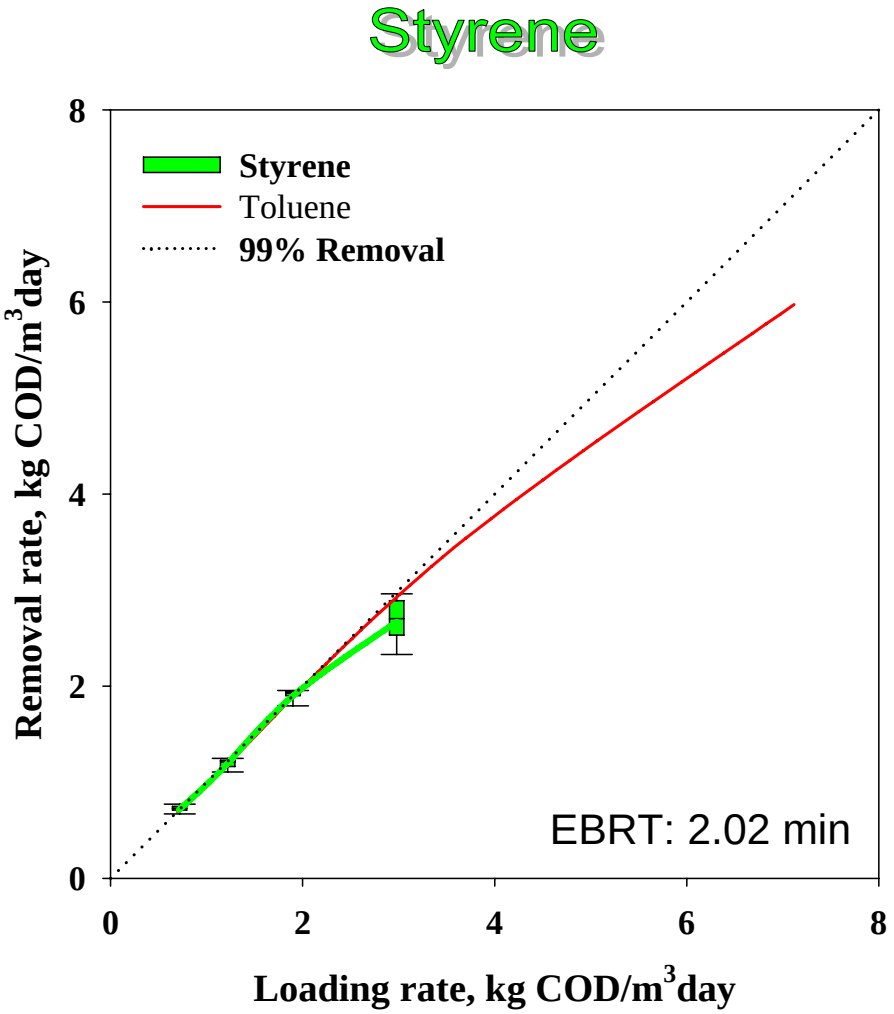


Results

Previous Study

- Critical loading
  1.9 kg COD/m^3·day
  (25.8 g/m^3·hr)
- Maximum removal capacity
  2.7 kg COD/m^3·day
  (36.6 g/m^3·hr)

Current study (EBRT: 2.02 min)
⇨ Inlet Conc. = 200 ppmv

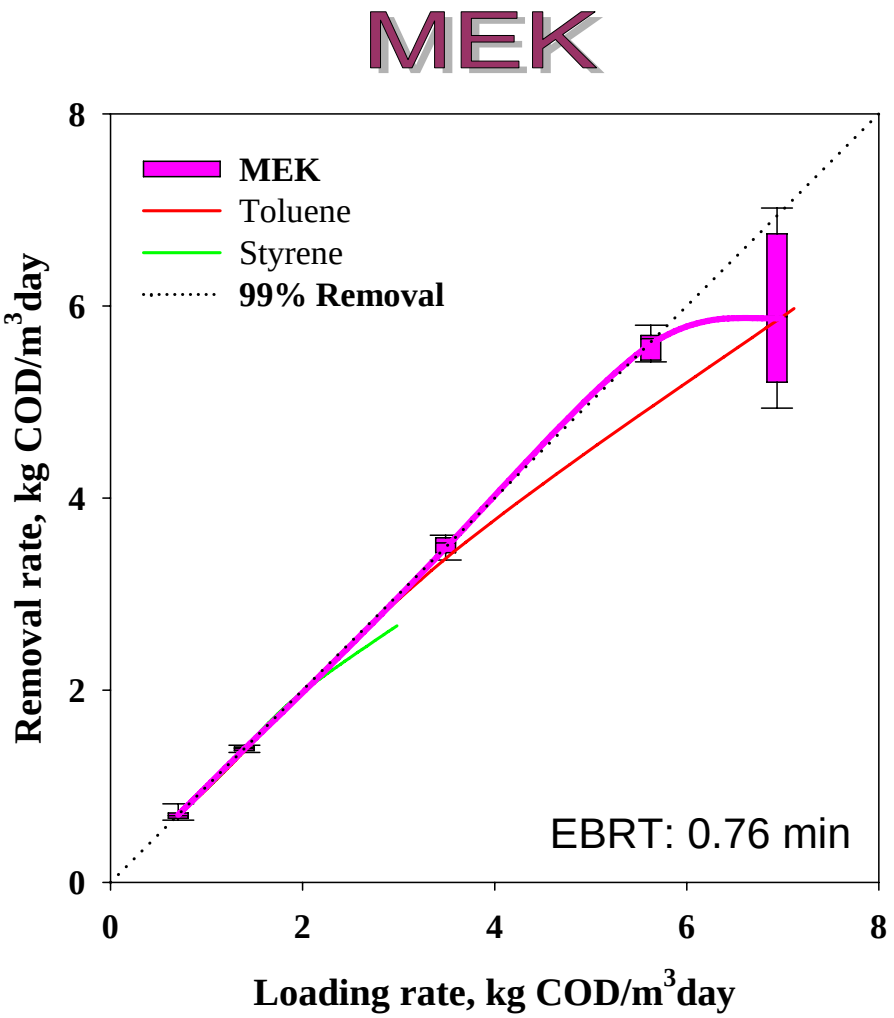


Results

Previous Study

- Critical loading
  5.6 kg COD/m^3·day
  (95.6 g/m^3·hr)
- Maximum removal capacity
  5.9 kg COD/m^3·day
  (100.7 g/m^3·hr)

Current study (EBRT: 2.02 min)
⇨ Inlet Conc. = 1075 ppmv

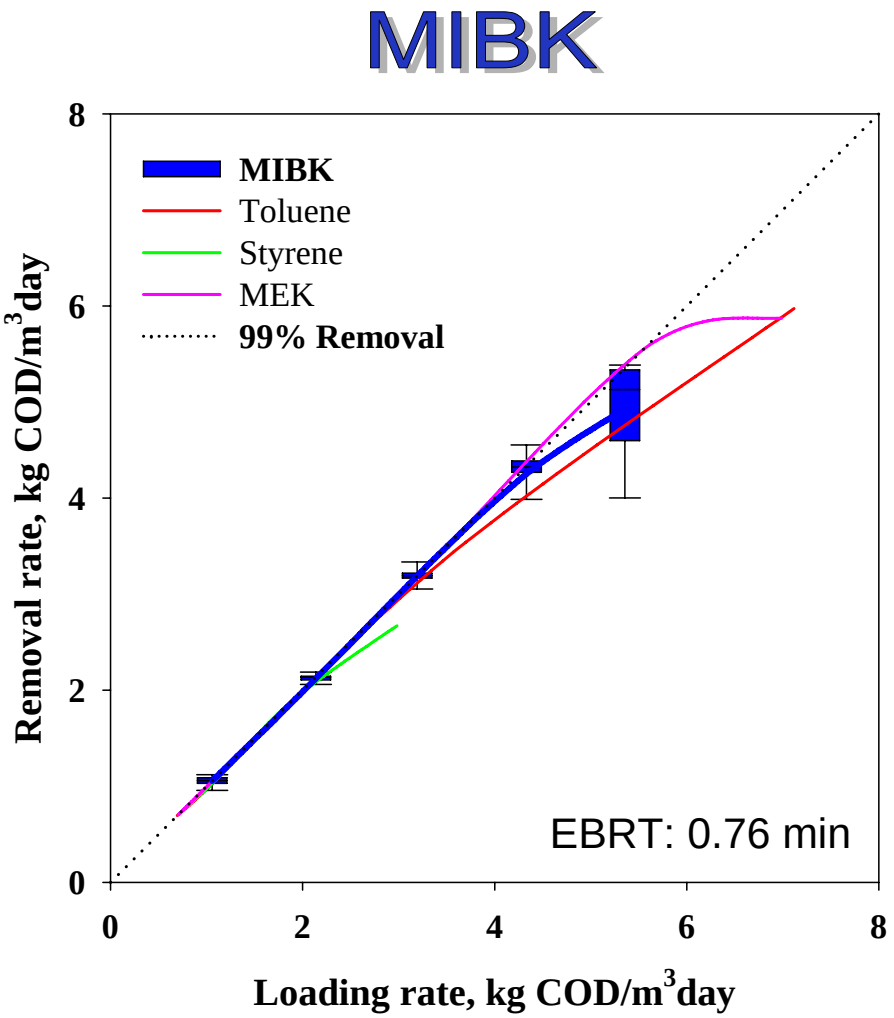


Results

Previous Study

- Critical loading
  4.3 kg COD/m^3·day
  (65.9 g/m^3·hr)
- Maximum removal capacity
  4.9 kg COD/m^3·day
  (75.1 g/m^3·hr)

Current study (EBRT: 2.02 min)
⇨ Inlet Conc. = 400 ppmv



Results

- **Current Study (interchange of the feed VOCs)**
  - **TBAB performance with respect to VOC removal**
  - **Effluent response corresponding to interchange of feeding VOCs**

    → **Removal efficiency**

    → **Nitrogen utilization and CO_2 production**

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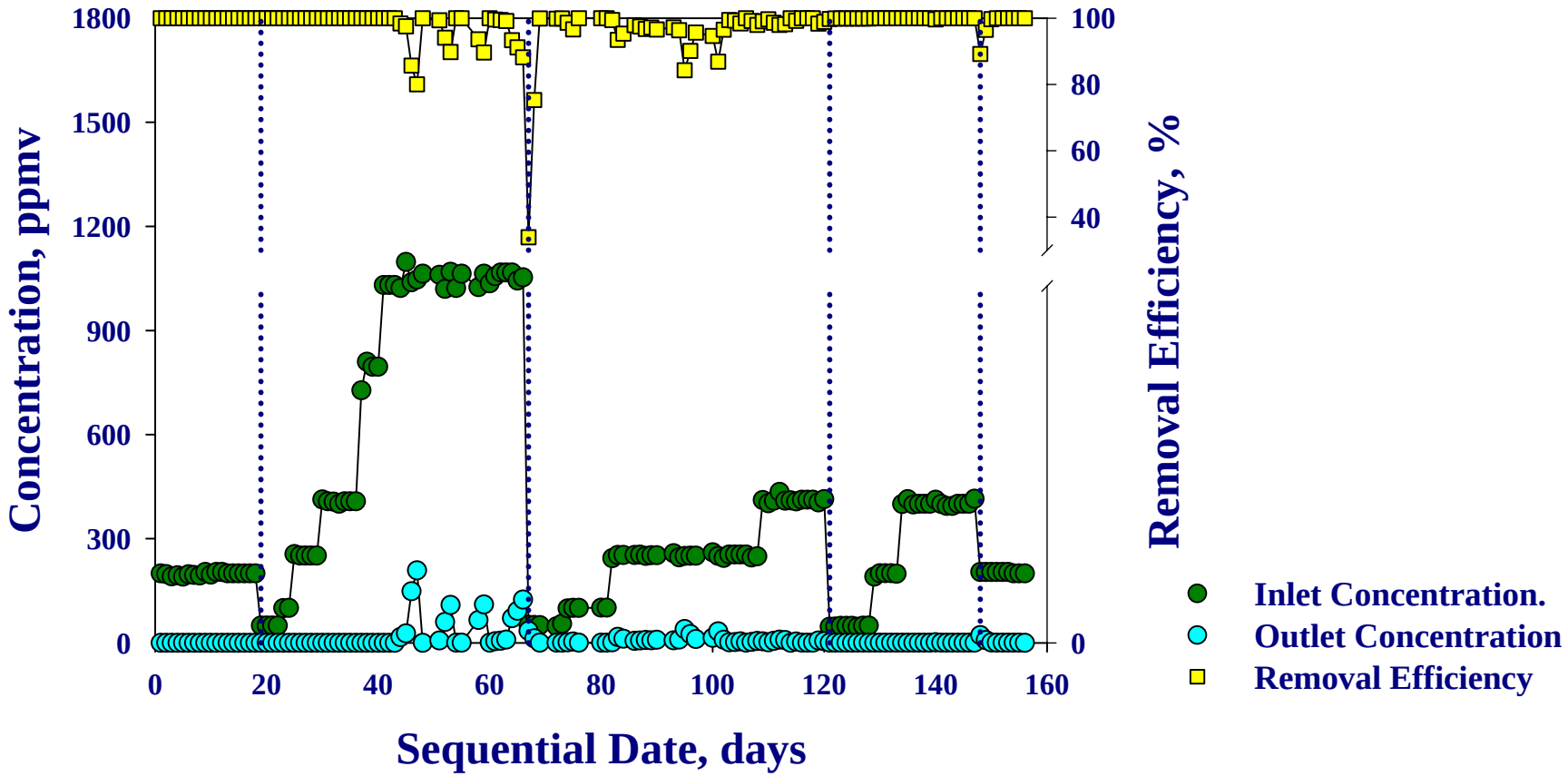
Results

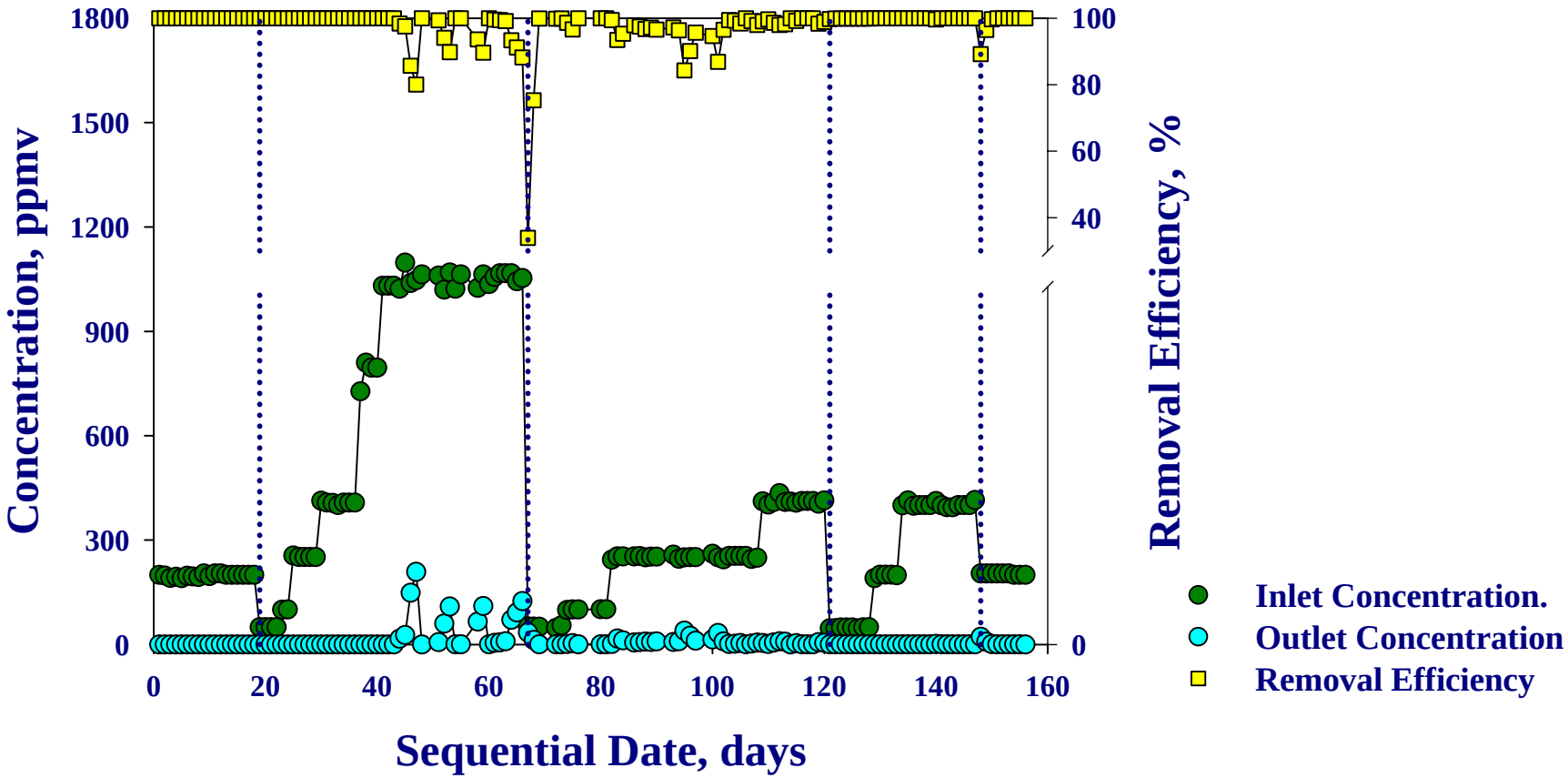
- **TBAB performance with respect to VOC removal**



Results

Styrene

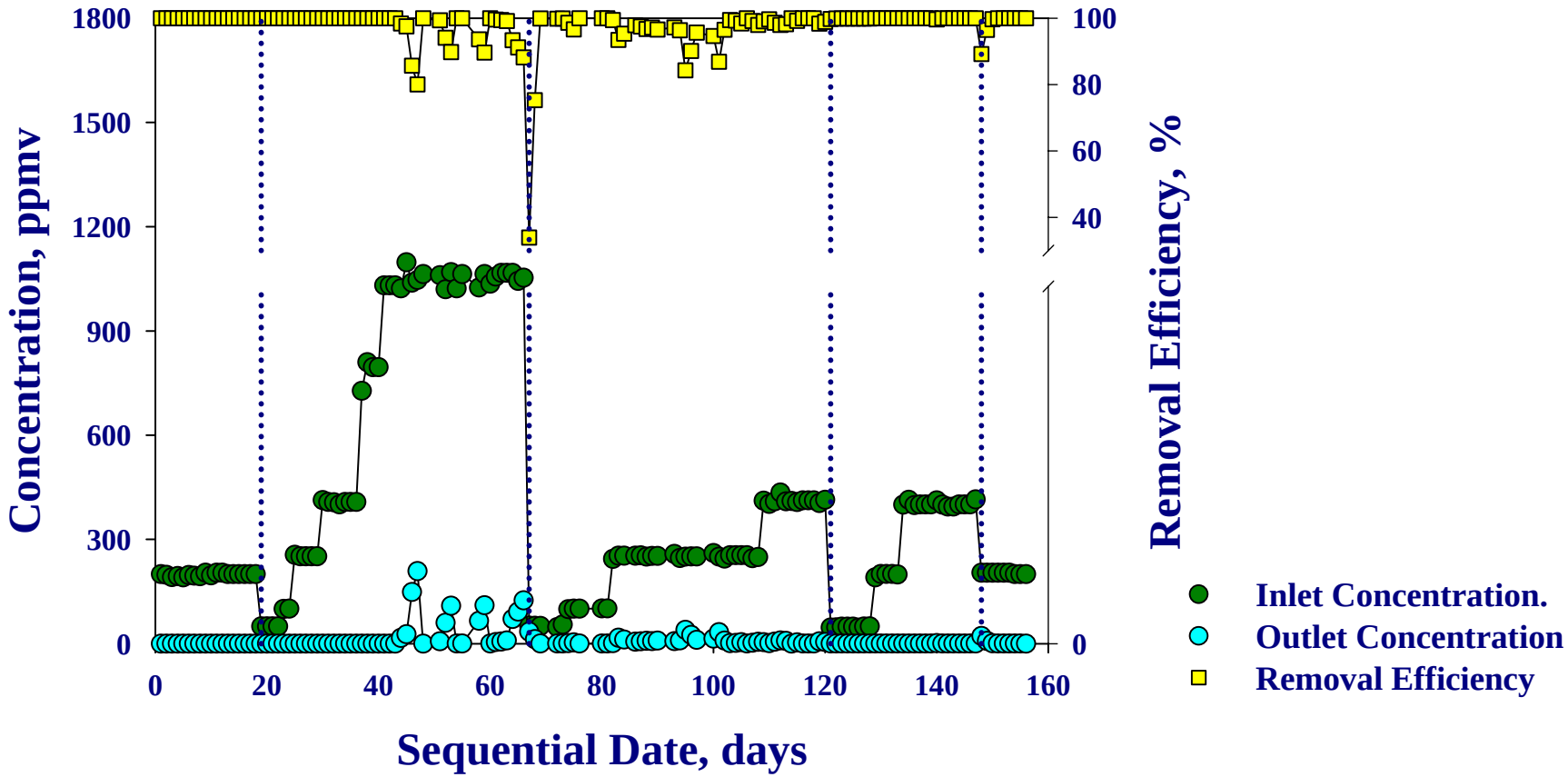
- Inlet: 200 ppmv



Results

MEK

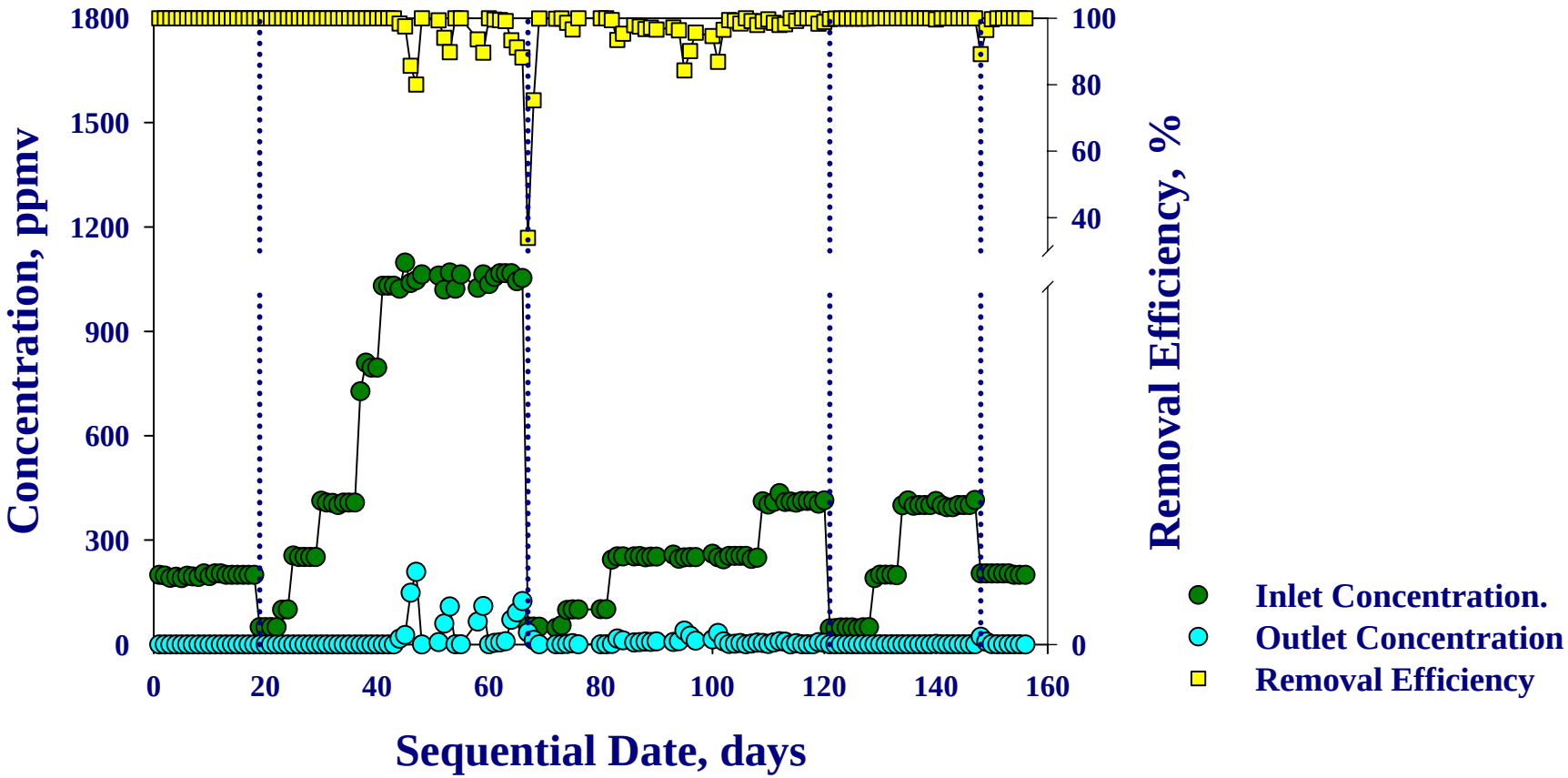
- Inlet: 50 - 1075 ppmv



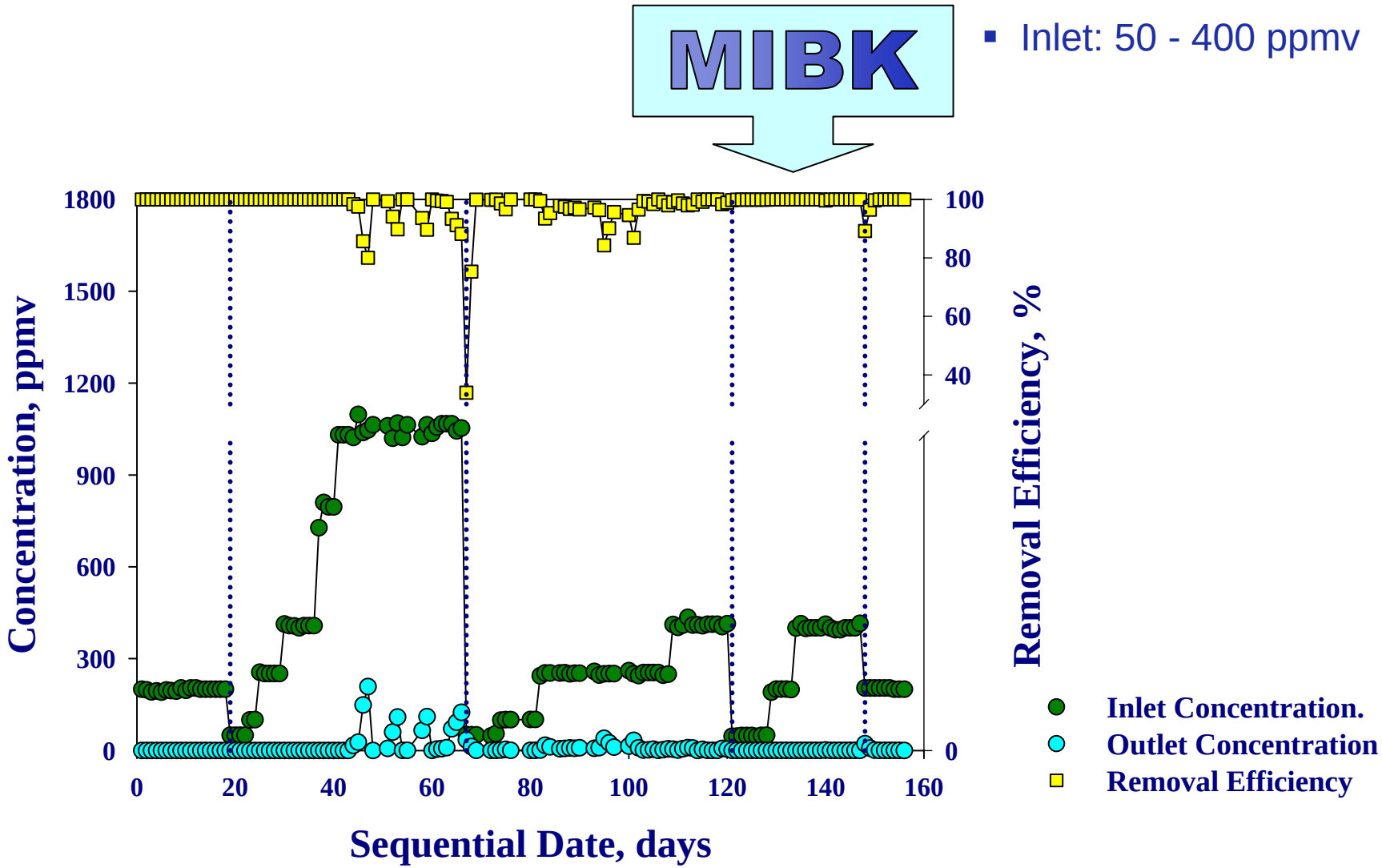
Results

Toluene

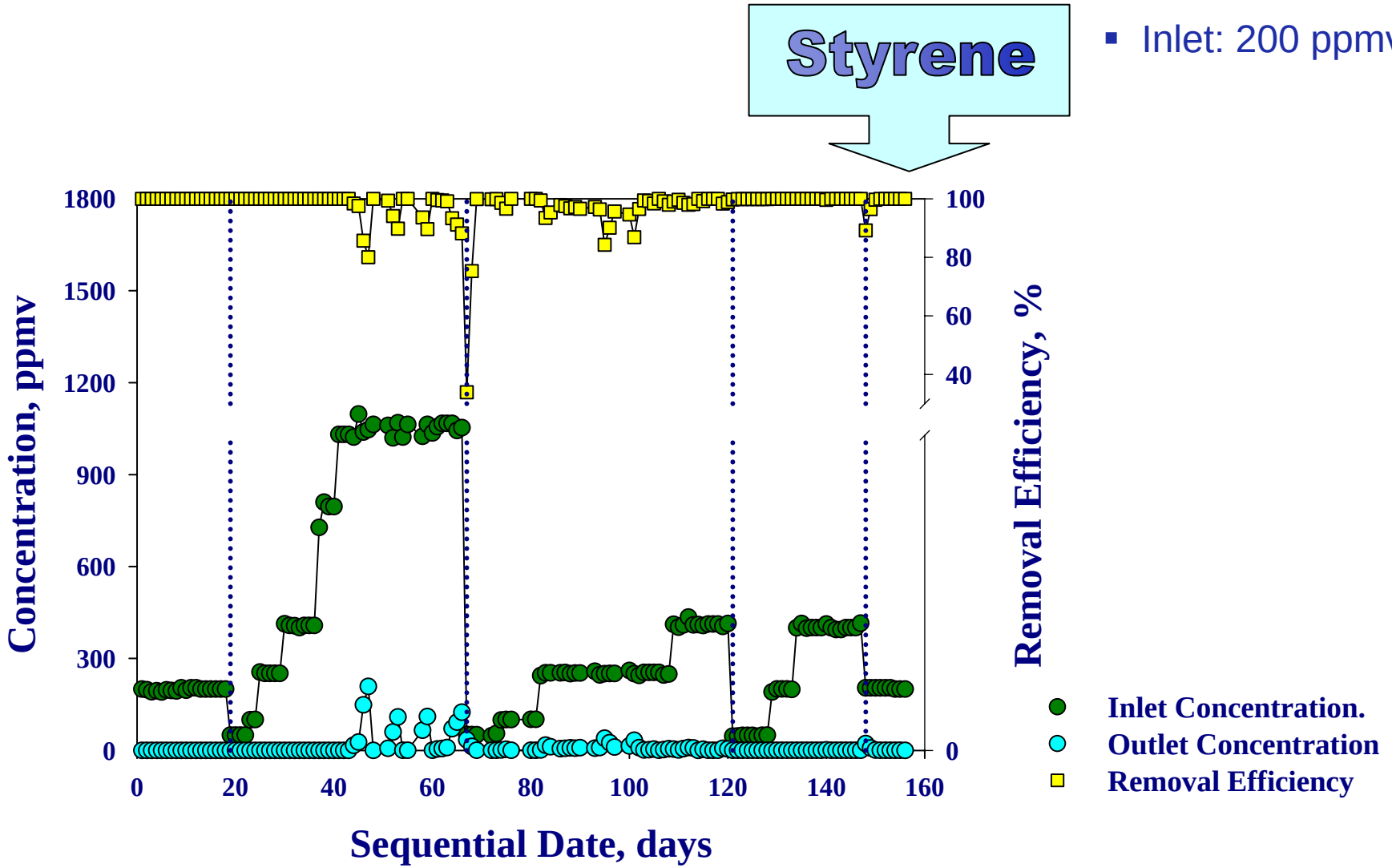
- Inlet: 50 - 400 ppmv



Results


MIBK
Inlet: 50 - 400 ppmv
Concentration, ppmv
Removal Efficiency, %
Sequential Date, days
1800
1500
1200
900
600
300
0
100
80
60
40
0
0
20
40
60
80
100
120
140
160
Inlet Concentration.
Outlet Concentration
Removal Efficiency

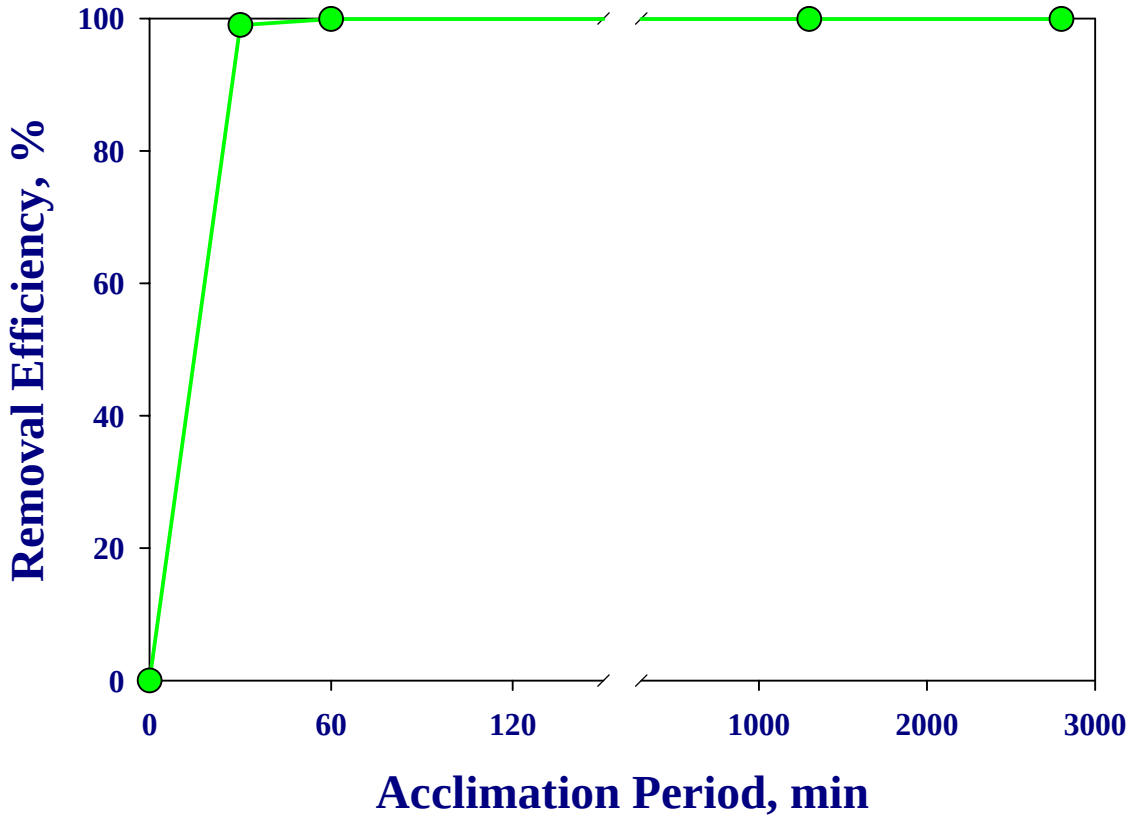
Results



- Inlet: 200 ppmv

Results

- Biofilter Response after interchanging VOCs



Styrene

⇩

MEK

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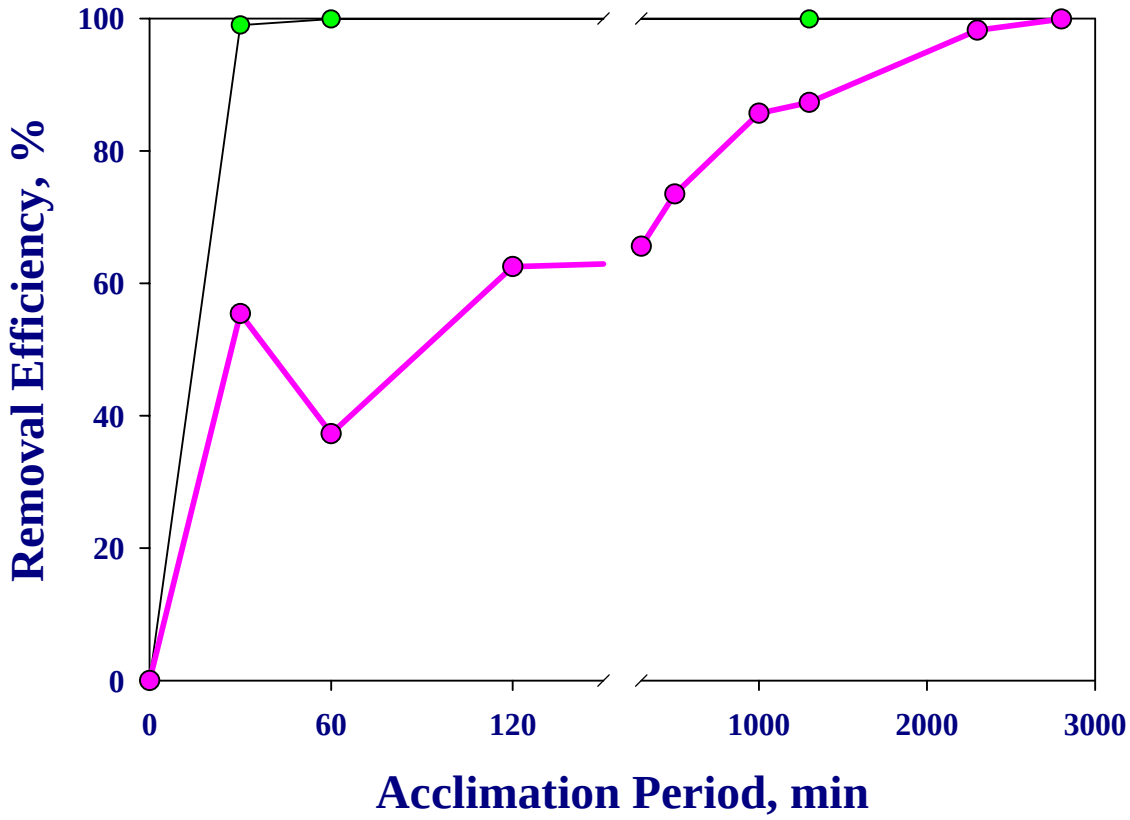
Results

- Biofilter Response after interchanging VOCs



Styrene

⇩

MEK

⇩

Toluene

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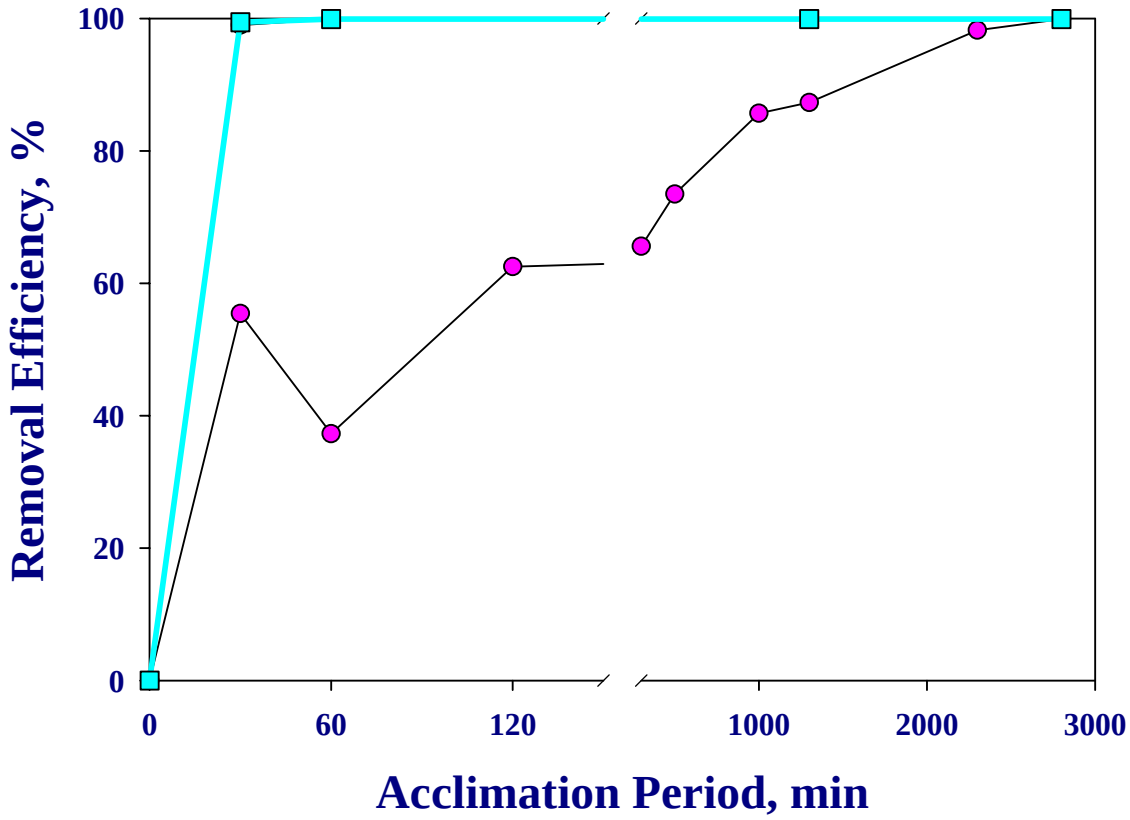
Results

- Biofilter Response after interchanging VOCs



Styrene

MEK

Toluene

MIBK

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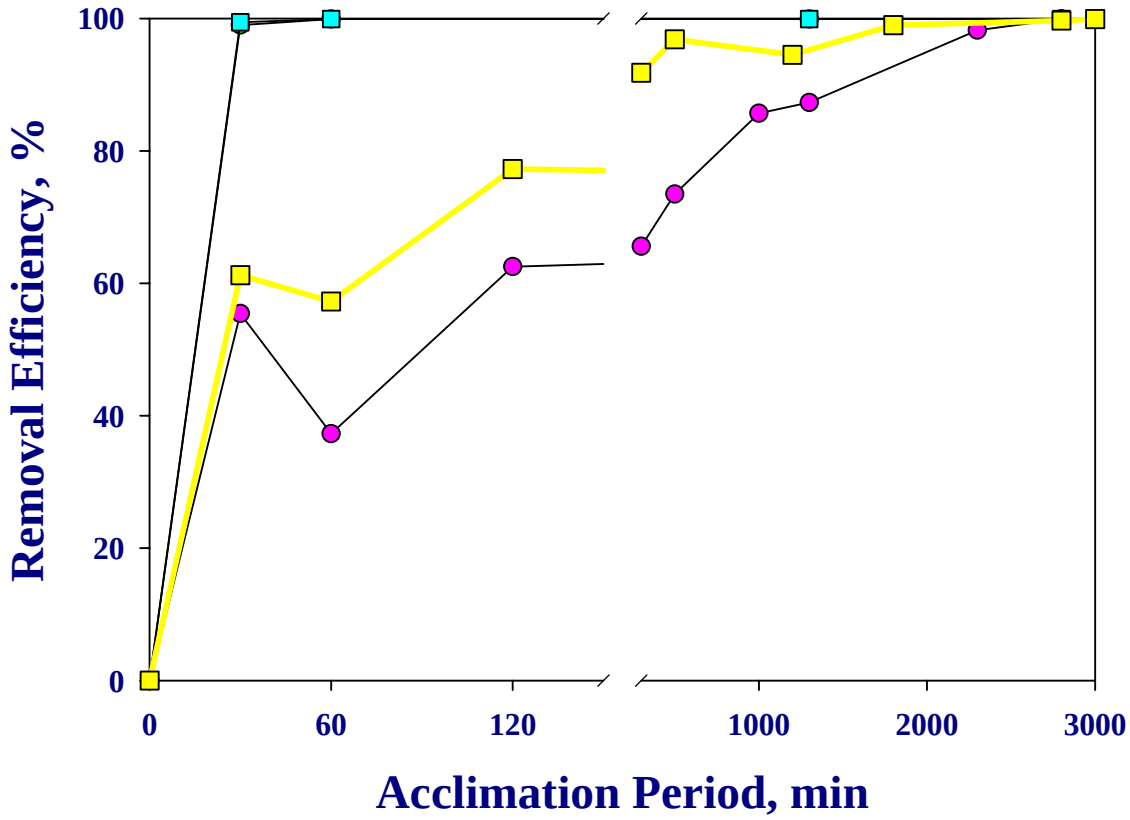
Results

- Biofilter Response after interchanging VOCs



Styrene

↓

MEK

↓

Toluene

↓

MIBK

↓

Styrene

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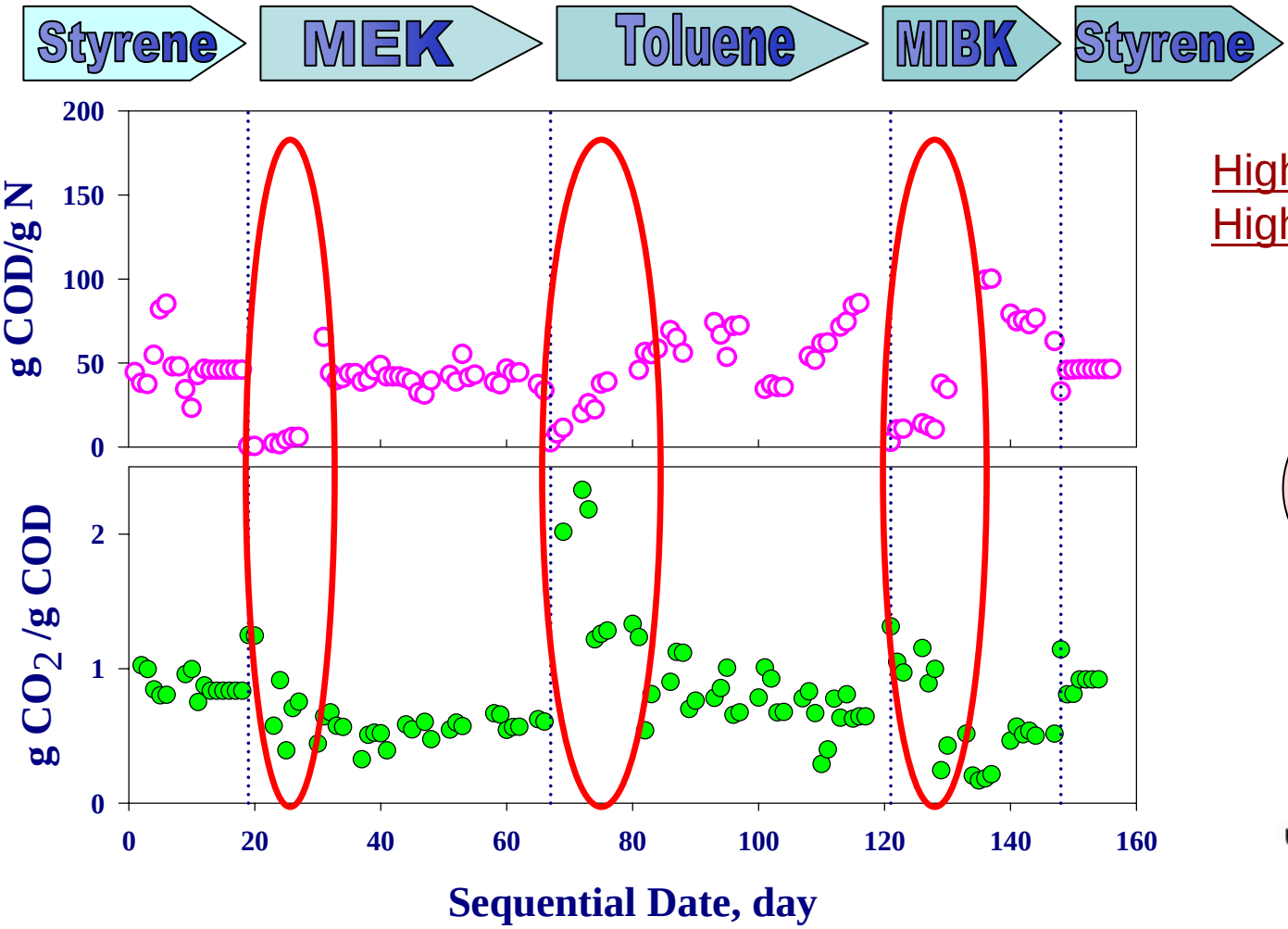
Results

- Nitrogen Utilization and CO_2 Production



High N utilization
High CO_2 /COD

Why?

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Discussion

High N utilization
High CO_2 /COD

Possbile Reason

1. Need more proteins to make up the enzymes for utilizing new substrate

- More utilization of nitrogen

2. Facultative organisms: Denitrifying microorganisms

- Nitrogen utilization and CO_2 Production

Study of Microbial community structure & diversity

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Conclusion

- High removal performances were observed in the interchanging VOC-fed TBAB.
- TBAB easily acclimated to hydrophilic compounds (MEK & MIBK), while TBAB acclimations to hydrophobic compound (Toluene & Styrene) were delayed for more than 45 hrs.
- Right after interchanging feeding VOCs, TBAB showed unusual performances (high nitrogen utilization & high CO_2/COD).

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Question?

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